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MINIMUM WAGES, EARNINGS AND EMPLOYMENT

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Minimum wages, Earnings and Employment

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Abstract

We analyze the impact of minimum wage regulations on employment and the earnings distribution using a micro-econometric framework. Account is taken of explicit minimum wage regulations in collective labour agreements. Thus we can identify the impact of minimum wage regulations on wage rates above the minimum using cross-section variation of minimum wages across sectors.

We estimate a static model and two dynamic models which include lagged employment status as an explanatory variable. In the latter models, long run and short run effects of changing minimum wage regulations can be distinguished.

Estimation and simulation results are based on data for Dutch males from three consecutive years. Minimum wage regulations appear to have a substantially negative effect on employment of young males and males with low education level, whereas the impact on wages of workers with a wage above the minimum appears to be significantly positive. The effects on both employment and earnings are larger than comparable US findings. In the dynamic models, long run elasticities of employment with respect to minimum wage rates exceed short run elasticities.

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1. Introduction

In this paper, we present several variants of a micro-econometric model to explain the distribution of employment and earnings. Emphasis is placed on the role of minimum wage regulations.

There exists an extensive literature of aggregate time series studies investigating the impact of the legal minimum wage on aggregate employment and average earnings. See Brown et al. (1982) for an overview of the US experience and, e.g., Bazen and Martin (1988) for a more recent study with French data. In these macro-economic studies, the obvious fact that the impact of minimum wage regulations strongly varies across education and age categories, is often neglected. Separate estimation for, e.g., youth and adults or males and females meets this objection to some extent.

In two articles by Meyer and Wise (1983a,b), data on individual wage rates are used to take full account of the labour market heterogeneity across individuals. Meyer and Wise allow for two effects of minimum wage regulations. Obviously, labour income of minimum wage earners depends on the level of the minimum wage. This is called the 'income effect' for minimum wage earners. The elasticity of minimum wage earners' earnings with respect to the minimum wage level is by definition equal to one and the importance of this effect for the average wage level depends on the fraction of workers earning the minimum. Secondly, a number of workers will be unemployed due to the fact that the minimum wage exceeds their marginal productivity. Thus, minimum wage regulations may have a negative impact on employment, particularly of low productivity workers.

In this paper, the Meyer and Wise model is extended and adjusted in several respects. In the first place, we do not consider the legal minimum wage, but minimum wages in collective labour agreements, which vary across sectors of the economy. Secondly, we account for the fact that minimum wages may affect wages above the minimum. Studies of e.g. Gramlich (1976) and Linneman (1982) suggest that such impacts are substantial. We thus relax the marginal productivity assumption, i.e. the assumption that wages are exclusively determined by the workers' marginal productivity. Finally, we include lagged employment as an explanatory variable. In this way, short run and long run effects of changes in minimum wage policies can be distinguished.

The paper is set up as follows. In section 2, we briefly review the Meyer and Wise model, which serves as a starting point for the analysis, and we introduce and motivate various model adjustments and extensions. The model is estimated with Dutch panel data spanning 1984 - 1987, some features of which are described in section 3. In section 4 the estimation results are presented, which are illustrated by some simulations in section 5. Section 6 concludes.

2. The model

We first describe the static version of the model. Incorporation of dynamic features will be discussed below. Starting point of the analysis is the 'general two-equation model' of Meyer and Wise (1983a, section B), describing employment and wage relationships in the absence of minimum wage regulations (the index indicating the individual has been suppressed):

$$E^* = X'\alpha + \varepsilon_1 \tag{1}$$

$$F^* = Y'\beta + \tilde{\varepsilon}_2 \tag{2}$$

Equation (1) reflects the possibility that someone does not work for reasons other than existing minimum wage regulations. This is the case if $E^*<0$. If $E^*>0$, then the individual would be employed if minimum wage regulations would not apply. Essentially, equation (1) is a reduced form equation with the same interpretation as the participation equation in Meyer and Wise (1983a,b) and Van Soest (1989). If $E^*<0$ then the individual does not work. If $E^*>0$, he or she may work, depending on minimum wage and marginal productivity. The vector X in principle includes all relevant observed individual characteristics, i.e. those which affect supply (preferences and the budget set), as well as those which affect demand. In this way, we also allow for involuntary unemployment which is not due to minimum wage regulations.

Note that the reduced form nature of (1) implies that the model does not distinguish between voluntary and involuntary unemployment. Contrary to Meyer and Wise, we do not a priori exclude any individuals between 16 and 65 years of age from the sample. Thus people with negative E^* may be students, disabled, retired, working without pay, involuntary unemployed due to other reasons than minimum wage regultations, etc.

Equation (2) defines the (natural) logarithm of the individual's productivity. It can be interpreted as the log of the maximum (before tax) wage rate a firm is prepared to pay the individual, if productivity can be measured without error and complete information about the worker's productivity is available, and if there are no adjustment costs. F^* clearly depends on individual characteristics which affect productivity. In the household data that we use, the observed characteristics relating to productivity are mainly age and education variables. Following Meyer and Wise (1983a), we shall take Y equal to X. Thus Y also includes variables referring to preferences, like e.g. family composition. These variables might be related to e.g. working attitude and thus indirectly affect productivity.

Meyer and Wise complete their model by comparing F^* with log M, where M is the legal minimum wage rate. If F^* exceeds log M, then the minimum wage rate has no impact, and the individual will be employed with log wage rate equal to F^*. His wage rate is then exclusively determined by marginal productivity. As a consequence, the model does not allow for an effect of minimum wage rates on above minimum earnings. If F^* is smaller than log M, Meyer and Wise distinguish three possibilities: The legal minimum does not apply (i.e. the relevant minimum is equal to 0), the worker is no longer hired because marginal costs (M) exceed marginal revenues ($\exp(F^*)$), or the worker is hired and paid the minimum.

The third possibility is not consistent with neoclassical marginal productivity theory in its simplest form. Meyer and Wise (1983b) present several explanations for this possibility, implying that the employer is able to increase the worker's marginal productivity beyond $\exp(F^*)$ ('marginal productivity in normal circumstances'), by reallocating tasks or reducing the level of non-wage compensation. Alternative explanations might be lack of information about the worker's productivity or the existence of adjustment costs such as e.g. firing and hiring costs.

In the Meyer and Wise model, the (before tax) wage rate is either equal to the marginal productivity or equal to the legal minimum. The explanation for the latter possibility may not be convincing from an economic point of view, but is necessary to explain the spike in the wage distribution at the minimum. In the data for The Netherlands which we use, such a spike at the legal minimum hardly exists. One possible explanation may be the existence of measurement errors in the observed wage rates. A model in which these measurement errors are explicitly incorporated is analyzed in Van Soest (1989).

In this paper we follow an alternative approach. Wage rates of most employees in The Netherlands are determined by collective labour agreements, including minimum wage regulations. This suggests that the minimum wage rate which is relevant for some individual is not the legal minimum, but the minimum agreed upon in his or her branch of industry. It is this relevant minimum wage rate which we shall incorporate in the model.

In the data, information about the individual's sector of employment is only available in rather aggregate form. Seven sectors are distinguished: agriculture, manufacturing, trade, transport, construction, banking and insurance, and other services. The observed average sector minimum is denoted by M. If the relevant sector is not known (as is the case for people who worked at none of the times of the interviews), M is defined as the weighted average of all sector minima. The relevant minimum is now given by equation (3):

$$T^* = \log M + \varepsilon_3 \tag{3}$$

Here T^* denotes the log of the (before tax) relevant minimum. The error term ε_3 represents deviations between the individual's relevant minimum and the sector average minimum. It seems reasonable to assume that the variance of the distribution from which ε_3 is drawn is larger in case the sector is not known than in case the sector is known.

Given (1)-(3), we may now distinguish various cases:

state I: $E^*<0$.

In this case the individual does not work, irrespective of the values of F^* and T^*. He is either voluntary unemployed or involuntary unemployed, but not due to minimum wage regulations.

state III: $E^*>0$, $F^*>T^*$.

In this case, the individual's productivity is large enough to make it attractive for the firm to hire him. Thus we assume that he will be employed. Furthermore, we generalize the Meyer and Wise assumption about the relation between wage and marginal productivity: We assume that the wage rate W is determined by both the productivity and the relevant minimum:

$$\log W = (1-\psi) F^* + \psi T^* \tag{4}$$

Here ψ is a parameter with $0 \le \psi \le 1$. If $\psi=0$ then the individual is paid according to productivity. This is the Meyer and Wise case. If $\psi>0$, then the wage rate is below marginal productivity. W can be seen as the outcome of a Nash bargaining process where F^* is the threat point of the firm and T^* is the threat point of the individual (see, e.g., Mortensen, 1986). ψ is thus positively related to the bargaining power of the firm. The higher ψ, the lower W. Throughout the empirical part of the paper we assume that ψ is the same for all individuals. It is in principle straightforward to allow ψ to depend on exogenous variables, such as the education level, such that ψ may vary across different types of jobs.

states II and IV: $E^*>0$, $F^*<T^*$

In this case the firm should, from the point of view of the standard neoclassical framework, not hire the individual. Thus, one possible outcome is that the individual is unemployed. Since $E^*<0$ refers to all sources of unemployment other than minimum wage regulations, every individual with $E^*>0$ would be employed if T^* were very low. Thus, unemployment of those with $E^*>0$ and $F^*<T^*$ can be interpreted as unemployment due to minimum wage regulations.

As noted above, several reasons can be suggested why the firm may, despite the low productivity, still be prepared to employ the individual and pay the minimum. The probability of this event is denoted by PT. We thus assume that if $E^*>0$ and $F^*<T^*$, two outcomes are possible: unemployment, with probability 1-PT, i.e. state II, and employment with wage rate T^*, with probability PT, i.e. state IV.

Summarizing, four states are distinguished:

I: unemployed for other reasons than minimum wage regulations
II: unemployed due to minimum wage regulations
III: employed and earning more than the minimum wage
IV: employed and earning the minimum wage.

Note that the specification of both the Meyer and Wise model and the extension introduced above imply that the employment effect of minimum wages is negative. In principle, there may also exist a positive effect of minimum wage regulations on employment. For this to be the case, three conditions must be satisfied: the minimum wage rate must positively affect expected earnings, labour supply must be a forward bending of expected earnings, and employment must be sensitive to labour supply changes, i.e. not exclusively be determined by labour demand. In our model, labour supply is determined by equation (1) and is not affected by minimum wages. Particularly for males, this assumption does not seem very harmful, since the empirical literature suggests that labour market participation and labour supply of males is hardly sensitive to wage rates (see, e.g., Pencavel, 1986).

The wage equation for people in state III can be rewritten as follows. Substituting (2) and (3) into (4) yields log $W = W^*$, where W^* is defined by

$$W^* = (1-\psi)Y'\beta + \psi \log M + (1-\psi)\tilde{\varepsilon}_2 + \psi\, \varepsilon_3 \qquad (5)$$

Moreover, $F^*>T^*$ is equivalent to $W^*>T^*$. Thus, throughout the model, F^* can be eliminated and replaced by W^*. This makes clear that the only difference between the wage equation (5) and the wage equation in the Meyer and Wise model is the fact that the minimum wage is included in the list of regressors. If log M would be a linear combination of the regressors included in Y, then ψ would not be identified, unless restrictions were imposed on the covariance structure of the error terms. The fact that M varies across sectors instead of with age only (as would be the case with the legal minimum) makes it possible to estimate ψ.

Equation (5) can be rewritten as a reduced form equation for W^*:

$$W^* = Y'\pi + \psi \log M + \varepsilon_2 \qquad (6)$$

Here $\pi=(1-\psi)\beta$ and $\varepsilon_2=(1-\psi)\tilde{\varepsilon}_2+\psi\varepsilon_3$. The Meyer and Wise hypothesis that the wage rates of people in state III equal their marginal productivity is thus simply the hypothesis that $\psi=0$.

In a competitive labour market equilibrium, the firms' marginal costs of labour are equal to the workers' marginal productivity, which corresponds to $\psi=0$. Interpreteing the fixed parameter ψ as the average value across different types of jobs, $\psi>0$ can be explained by the fact that their is monopsonistic power among firms for some types of labour. The pure monopsony case would, in case of inelastic labour supply, imply that ψ would be equal to 1. ψ will be smaller than 1 because firms do compete and workers do cooperate. In The Netherlands, wages are to a large extent determined by collective agreements between employer organisations and unions. Therefore, the bargaining process might well be a better description of the Dutch labour market than the competitive model.

We assume that the vector of error terms $(\varepsilon_1,\varepsilon_2,\varepsilon_3)'$ in the model is drawn from a trivariate normal distribution with mean $(0,0,0)'$ and covariance matrix Σ. By way of normalisation, $\Sigma(1,1)$ is set equal to 1. In the empirical part of the paper, $\Sigma(1,3)$ has been set equal to 0. If $\psi>0$, it does not seem reasonable to assume that $\Sigma(2,3)=0$, considering the fact that ε_2 is defined as $(1-\psi)\tilde{\varepsilon}_2+\psi\varepsilon_3$. If we assume that $\mathrm{Cov}(\tilde{\varepsilon}_2,\varepsilon_3)=0$, then we have $\Sigma(2,3) = \psi\Sigma(3,3)$. This yields an extra source of identification of ψ. Finally, we shall work with different values of $\Sigma(3,3)$, depending on whether someone's sector of employment is known or unknown. The difference between $\sqrt{\Sigma(3,3)}$ for those with unknown sector and $\sqrt{\Sigma(3,3)}$ for those with known sector will be set equal to 0.05, corresponding to the variation in log M across sectors.

The static model introduced above can be used to investigate to what extent unemployment is caused by minimum wage regulations and in which way minimum wage regulations affect the earnings distribution. Under extra assumptions (mainly *ceteris paribus* conditions), it can be used to predict the effects of changes in relevant minimum wages for employment and earnings of various types of workers. It does however not reveal the lags with which such effects will come about.

A first step towards a dynamic model is to incorporate lagged endogenous variables. Obviously, various features of someone's labour market history may have been of influence on his or her present labour market status. The only lagged variable which we take into account is a dummy variable indicating whether or not the individual was employed one year before the time of the interview. The lagged wage rate is not included. Taking into account the fact that this wage rate may refer to either lagged productivity or the lagged relevant minimum would add too much complexity to the model. Moreover, for many individuals, including all those who were not employed one year before the time of the interview, no lagged wage rate has been observed.

Neither did we include lagged exogenous variables, although this would have been straightforward. Variation across time of the main exogenous variables, related to education and age, appears too small to include their lagged values.

The dummy variable referring to lagged employment is denoted by DELAG, where DELAG=1 and DELAG=0 mean that the individual was and was not employed one year before the time of the interview, respectively. Lagged employment is assumed to play a role in three different ways. In the first place, DELAG is added as a regressor to the E^*-equation (equation (1)). A positive impact of DELAG on E^* may for example be interpreted as habit formation: People who worked in the past have stronger preferences for work than those who did not. On the other hand, DELAG also picks up time-persistent unobserved heterogeneity, which in the static model was included in the error term ε_1. In the dynamic model, ε_1 has mean zero, conditional on the past. Accordingly, in the dynamic model, the interpretation of both the error term and the systematic part $X'\alpha$, is different from its counterpart in the static model.

Secondly, DELAG is added to the regressors in equation (6). A positive impact of DELAG on W^* can be interpreted as an extra way (apart from age) in which the impact of working experience on productivity is reflected. Such a positive *ceteris paribus* impact of DELAG on productivity does not necessarily imply that working is a better way of improving productivity than not working. Particularly for young people, education may well be a better alternative. This will be measured by the positive impact of the education variables in equation (6).[1)]

Finally, lagged employment is allowed to affect the probability PT that low productivity workers are employed and receive the minimum. We have noted above that PT>0 cannot be explained in a standard neoclassical framework. In our view, the presence of adjustment costs such as e.g. costs associated with hiring and firing employees might provide a feasible explanation. This implies that an employed worker may not be fired immediately if his productivity falls below the minimum. On the other hand, it does not explain why unemployed low productivity workers would be hired. Thus, we would expect PT to be larger for those with DELAG=1 than for those with DELAG=0. If we ignore the possibility that, within one year, an unemployed worker is first hired since his productivity exceeds the minimum, and that after this his productivity falls below the minimum, then it seems reasonable to assume that PT=0 for those with DELAG=0. In what follows, PT for those with DELAG=1 and DELAG=0 will be denoted by PTE and PTU, respectively.

The explanation given above is similar to a partial adjustment mechanism. If $W^*<T^*$ and $E^*>0$, the 'optimal' labour market status in a static framework, ignoring adjustment costs etc., is unemployment. For an employed worker, 1-PT can be interpreted as the probability that the transition from employment to unemployment indeed takes place, and PT is the probability that it does not take place.

On the other hand, we still assume that if $E^*<0$ the individual will certainly not work, even though he was working previously. This is because lagged unemployment is already incorporated as a regressor in the E^*-equation itself. Moreover, we expect that adjustment costs will on average not play an important role here, since $E^*<0$ mainly refers to non-participation or voluntary unemployment.

Following the partial adjustment argument, it might also be considered to introduce the possibility that, if the static model predicts a change from unemployment to employment, the transition does not occur. Preliminary estimation results however suggested that the probability of this is zero.

The likelihood function

Both the static and the dynamic model are estimated by Maximum Likelihood. We describe the likelihood contribution of each individual in the sample for the static case, leaving the dynamic case as a straightforward extension.

Apart from the model assumptions given above, an extra assumption is needed to take account of the fact that not all wage rates of workers are observed. As in Meyer and Wise (1983a), we assume that the event that a worker's wage rate is not observed is independent of the other random variables in the model. The probability of this event may depend on the exogenous variables and is denoted by PU.

As in the Meyer and Wise model, it is not observed whether an unemployed person is unemployed due to minimum wage regulations ($E^*>0$, $W^*<T^*$) or because of some other reason ($E^*<0$). Due to the error term in the minimum wage equation, it is also not observed with certainty whether a worker's wage rate is above, below, or equal to the (relevant) minimum, even if this wage rate is observed. This lack of information is an important difference with the Meyer and Wise models, which suggests that particularly the parameters PT (or, in the dynamic model, PTU and PTE) and the covariance matrix of the error terms might be harder to estimate than in the Meyer and Wise case. Moreover, the sensitivity of the results with respect to chosen distributional assumptions might be larger.

Three observed categories of sample observations can be distinguished: non-workers, workers whose wage rates are not observed, and workers with known wage rate. The likelihood contribution L_i of individual i in either one of these three categories can be written as a sum of two probabilities, corresponding to different states:

a. non-workers are either in state I or state II:

$$L_i = \Pr[\varepsilon_{1i} < -X_i'\alpha] + (1-PT)\Pr[-\varepsilon_{1i} < X_i'\alpha \text{ and } \varepsilon_{2i} - \varepsilon_{3i} < -Y_i'\pi + (1-\gamma)\log M_i]$$

This is a linear combination of a univariate and a bivariate normal cumulative probability.

b. workers with unknown wage rate are either in state III or state IV:

$$L_t = PU\,\{\Pr[-\varepsilon_{1i} < X_i'\alpha \text{ and } \varepsilon_{3i} - \varepsilon_{2i} < Y_i'\pi - (1-\gamma)\log M_i] + \Pr[-\varepsilon_{1i} < X_i'\alpha \text{ and } \varepsilon_{2i} - \varepsilon_{3i} < -Y_i'\pi + (1-\gamma)\log M_i]\,PT\}$$

c. workers with known wage rate W_i are either in state III or state IV.
Let $a1 = \log W_i - Y_i'\pi - \gamma \log M_i$, $a2 = \log W_i - \log M_i$, and let f_1 and f_2 be the (normal) probability density functions of ε_{2i} and ε_{3i}, respectively. Then the likelihood contribution is given by:

$$L_t = \{1-PU\}\{\Pr[-\varepsilon_{1i} < X_i'\alpha \text{ and } \varepsilon_{3i} - \varepsilon_{2i} < Y_i'\pi - (1-\gamma)\log M_i \mid \varepsilon_{2i} = a1]\,f_1(a1) +$$

$$\Pr[-\varepsilon_{1i} < X_i'\alpha \text{ and } \varepsilon_{2i} - \varepsilon_{3i} < -Y_i'\pi + (1-\gamma)\log M_i \mid \varepsilon_{3i} = a2]\;PT\;f_2(a2)\}$$

The two conditional probabilities are both bivariate normal and corresponding means and variances can easily be derived (see, e.g., Johnson and Kotz, 1972).

Note that the value of PU will have no impact on the ML-estimates of the other parameters, irrespective of whether PU is allowed to vary with the exogenous variables or not. In the remainder of the paper, we do not pay attention to estimation of PU.

3. The Data

The analysis in this paper is restricted to males between 16 and 65 years of age. We used data from various waves of the 'Socio Economic Panel', collected by The Netherlands Central Bureau of Statistics. We combined data collected in October 1985, October 1986 and October 1987. For the construction of DELAG, we also used the October 1984 wave. The panel nature of the data was used in order to construct the lagged employment dummy and to correct wrong or missing information, mainly on the exogenous variables. Information on the sample composition is presented in table 1.

Table 1. Sample Composition

	Oct. '85	Oct. '86	Oct. '87
DELAG=0:			
Working, wage rate known:	78	95	120
Working, wage rate unknown:	38	30	22
Not working:	510	618	771
subtotal:	626	743	913
DELAG=1:			
Working, wage rate known:	1557	1862	2387
Working, wage rate unknown:	234	259	255
Not working:	84	93	136
subtotal:	1875	2214	2778
All sample individuals:			
Working, wage rate known:	1635	1957	2507
Working, wage rate unknown:	272	289	277
Not working:	594	711	907
total:	2501	2957	3691

The table reveals a strong positive correlation between employment status one year ago and actual employment status. The number of individuals with DELAG=0 who are currently working and whose wage rates are observed appears to be rather small.

In the empirical analysis, the following exogenous variables are included in the vectors X and Y:

CONST: constant term

DED2, DED3, DED4 and DED5: dummy variables referring to the individual's education level. At the lowest level, all dummies are 0. At the third level DED3=1 and DED2=DED4=DED5=0, etc.

LAGE: the logarithm of the individual's age at the time of the interview.

L2AGE: LAGE-squared.

LADED3: DED3*LAGE.

LADED45: (DED4+DED5)*LAGE.

DRAN: dummy variable; DRAN=1 if the family lives in the western part of The Netherlands ('Randstad'); DRAN=0 otherwise.

UNP: unemployment rate in the region where the individual lives (11 regions are distinguished)

NCH: the number of children in the family (NCH=0 if the individual is not one of the parents).

DCH6: dummy variable; DCH6=1 if the individual has children younger than six, DCH6=0 otherwise.

DSI: dummy variable; DSI=1 in case of a one-person household; DSI=0 otherwise.

DHP: dummy variable; DHP=1 if the individual is the head of a family and DSI=0; DHP=0 otherwise.
D86: dummy variable; D86=1 for an observation in 1986; D86=0 otherwise.
D87: dummy variable; D87=1 for an observation in 1987; D87=0 otherwise.

Sample statistics of these exogenous variables, the minimum wage rate M, and the observed wage rates W, are given in table 2. Sample statistics of W relate to those with known wage rate only. Separate statistics are given for those who were unemployed and those who were employed a year ago. On average, the wage rate for those with DELAG=0 appears to be substantially lower than for those with DELAG=1.

Table 2. Sample Statistics

VARIABLE	MEAN	STANDARD DEVIATION	MINIMUM VALUE	MAXIMUM VALUE
log M	2.381	0.217	1.451	2.601
DED2	0.220	0.414	0.000	1.000
DED3	0.419	0.493	0.000	1.000
DED4	0.119	0.323	0.000	1.000
DED5	0.053	0.224	0.000	1.000
LAGE	3.581	0.351	2.833	4.159
L2AGE	12.948	2.481	8.027	17.296
LADED3	1.509	1.788	0.000	4.159
LADED45	0.632	1.391	0.000	4.159
DRAN	0.403	0.491	0.000	1.000
UNEMP	0.148	0.021	0.097	0.227
NCH	0.876	1.092	0.000	6.000
DCH6	0.219	0.414	0.000	1.000
DHP	0.766	0.423	0.000	1.000
DSI	0.080	0.271	0.000	1.000
W, All:	24.856	14.963	2.330	539.045
W, DELAG=0:	15.405	11.692	2.330	121.425
W, DELAG=1:	25.332	14.952	2.640	539.045

Table 3 provides some information about the ratio of the observed wage rate W to the observed average minimum wage rate M. The table shows that the number of people earning exactly the average sector minimum is small. In this respect, our data differ substantially from the Meyer and Wise data. Several explanations can be suggested. The first possibility is that PT is very small. Secondly, the average minimum may be a poor approximation of the relevant minimum for a given individual. These two explanations are allowed for in the model introduced in the previous section. A third possibility, a measurement error in the observed wage rate W, has been modelled in Van Soest (1989).[2)]

Table 3. Observed Actual and Minimum Wage Rates

W/M	education level 1	2	3	4	5	age class 1	2	3	4	5	total
<0.90	2.8	1.8	1.4	0.4	0.5	5.6	1.2	0.8	0.9	1.9	1.5
≥0.90,<0.95	1.4	0.6	0.4	0.2	0.3	2.1	0.3	0.2	0.7	0.6	0.5
≥0.95,<1.00	0.8	0.6	0.5	0.2	0.0	2.3	0.6	0.1	0.3	0.0	0.5
≥1.00,<1.05	1.7	1.6	0.5	0.0	0.0	2.5	0.8	0.6	0.4	0.3	0.8
≥1.05,<1.10	1.2	1.8	0.8	0.0	0.2	3.9	0.7	0.3	0.6	0.8	0.9
≥1.10	92.1	93.5	96.4	99.1	98.9	83.6	96.4	98.0	97.0	96.4	95.8

Explanation:
cell entries are percentages of column totals.
education levels: see definition of DED2, DED3, etc.
age bracket 1: 16-24, 2: 25-34, 3: 35-44, 4: 45-54 5: 55-64.

4. Estimation Results

Several specifications of the model have been estimated by maximum likelihood, using the algorithm of Berndt et al. (1974). Estimation results for one static and two dynamic versions are presented in table 4.

The estimate of $\Sigma(3,3)$, the variance of the error term in the minimum wage equation, is surprisingly large. One reason might be the fact that we did not explicitly allow for the possibility that no minimum is relevant (i.e. the probability P_1 in the Meyer and Wise model is set equal to 0). In our model, the minimum will play no role if ε_3 is much smaller than 0.

The estimated covariance between the error terms in the E^*- and W^*-equations is not significantly different from 0. This corresponds to the common empirical finding that the participation decision of males is insensitive with respect to the wage rate.

We have imposed the restriction $\Sigma(2,3) = \psi\,\Sigma(3,3)$, corresponding to the assumption that $\tilde{\varepsilon}_2$ in equation (2) and ε_3 in equation (3) are independent. The static model was also estimated without imposing this restriction. The restriction was not rejected by a likelihood ratio test at the 5% level (the value of the test statistic being 2.94, with critical value $\chi^2_{1;0.05} = 3.84$). Moreover, the estimates and their standard errors in the restricted and unrestricted case appeared to be almost identical.

Table 4. Estimation Results

	Static model parameter	Static model st. error	Dynamic Model; PTU=0 parameter	Dynamic Model; PTU=0 st. error	Dynamic Model; PTU=PTE parameter	Dynamic Model; PTU=PTE st. error
$\sqrt{\Sigma(2,2)}$	0.338	0.003	0.335	0.003	0.339	0.003
$\sqrt{\Sigma(3,3)}$[3]	0.360	0.019	0.367	0.019	0.382	0.019
$\rho(1,2)$	-0.003	0.147	0.035	0.130	0.059	0.149
$\rho(2,3)$	0.173	-----	0.194	-----	0.114	-----
PTU	0.398	0.069	0.000	-----	0.749	0.031
PTE	0.398	0.069	0.698	0.037	0.749	0.031
E*equation						
CONST	-76.311	3.510	-50.129	4.683	-44.780	3.890
DED2	0.271	0.070	0.235	0.102	0.233	0.087
DED3	-2.574	0.452	-1.758	0.664	-1.642	0.579
DED4	-6.506	0.893	-1.878	1.207	-0.906	1.107
DED5	-6.487	0.886	-1.843	1.214	-0.879	1.116
LAGE	45.320	2.052	30.727	2.745	27.312	2.276
L2AGE	-6.545	0.291	-4.618	0.392	-4.111	0.326
LADED3	0.777	0.121	0.537	0.183	0.516	0.163
LADED45	1.824	0.232	0.549	0.316	0.316	0.292
DRAN	0.037	0.056	-0.198	0.085	-0.146	0.076
UNP	-3.393	1.270	-4.077	2.105	-4.206	1.821
NCH	0.242	0.057	0.077	0.068	0.094	0.062
DCH6	0.092	0.202	-0.353	0.180	-0.332	0.161
DHP	0.436	0.128	-0.233	0.169	-0.098	0.140
DSI	-0.398	0.121	-0.661	0.163	-0.520	0.135
D86	-0.067	0.065	0.030	0.096	0.004	0.084
D87	-0.111	0.061	-0.149	0.089	-0.133	0.080
DELAG	-----	-----	3.424	0.119	3.433	0.116
W*-equation						
CONST	-10.462	1.765	-10.960	1.000	-11.516	1.060
DED2	0.100	0.017	0.070	0.017	0.073	0.018
DED3	-0.205	0.157	-0.282	0.143	-0.236	0.150
DED4	-1.332	0.224	-1.450	0.187	-1.387	0.193
DED5	-1.171	0.225	-1.292	0.189	-1.227	0.196
LAGE	6.844	1.021	7.044	0.582	7.400	0.611
L2AGE	-0.907	0.145	-0.936	0.081	-0.983	0.085
LADED3	0.125	0.043	0.135	0.039	0.124	0.041
LADED45	0.512	0.061	0.533	0.051	0.517	0.052
DRAN	0.085	0.010	0.081	0.010	0.083	0.011
UNP	-0.599	0.268	-0.446	0.267	-0.436	0.276
NCH	-0.016	0.005	-0.014	0.005	-0.015	0.005
DCH6	0.017	0.013	0.021	0.013	0.022	0.014
DHP	0.149	0.026	0.138	0.026	0.157	0.028
DSI	0.061	0.032	0.072	0.030	0.091	0.032
D86	0.007	0.012	0.003	0.012	0.006	0.013
D87	0.042	0.012	0.037	0.012	0.039	0.012
log M	0.162	0.048	0.178	0.045	0.101	0.046
DELAG	-----	-----	0.152	0.053	0.190	0.068

In the static model, the estimate of PT (=PTU=PTE) is 0.398, with corresponding standard error 0.069. This would imply that a substantial number of low productivity workers are paid above their productivity. 60% of workers with productivity below the minimum are not employed. What this implies for the extent to which unemployment can be attributed to minimum wage regulations will be discussed below.

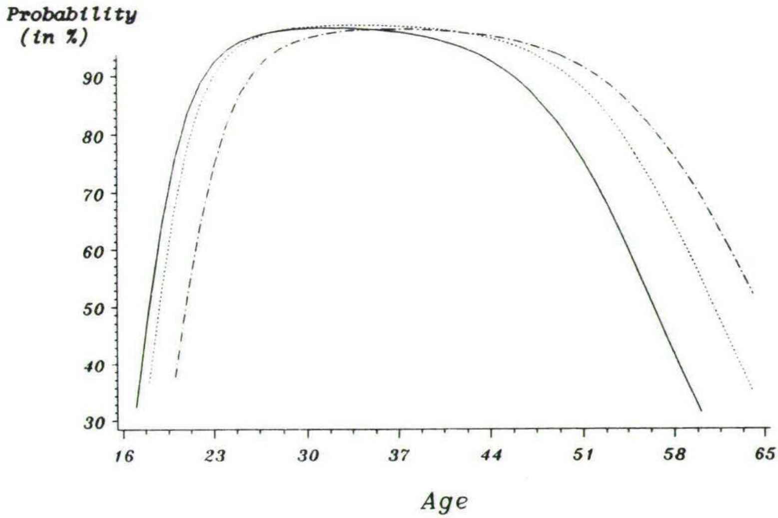
In the dynamic model with PTU=0, the fact that low productivity workers are still employed is explained by the presence of adjustment costs. People who previously had no job (DELAG) do not have this opportunity. The resulting estimate for people with DELAG=1 is almost 0.7 with a surprisingly small standard error of 0.037. The results of the static and the dynamic model are in agreement with each other, in the sense that PT is some weighted average of PTE and PTU.

Supplementary estimation results show however that this conclusion may be premature. Estimation of the dynamic model without imposition of PTU=0 yields PTU=0.97, with standard error of 0.37. This estimate may be inaccurate, but it is significantly different from 0. The corresponding estimate of PTE is 0.75 (with standard error 0.03). The fact that PTU exceeds PTE contradicts economic intuition. Moreover, the values of PTE and PTU now both strongly exceed the value of PT in the static model.

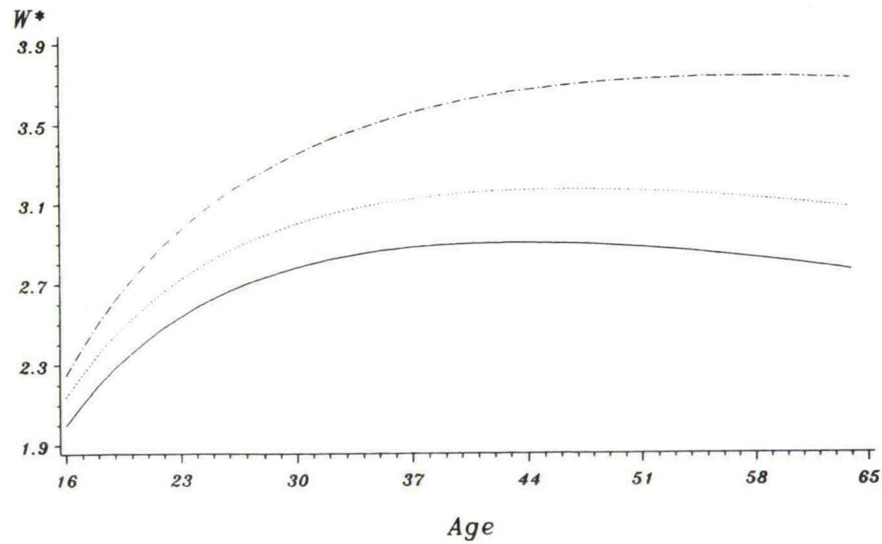
These results suggest that it is worthwile to estimate the dynamic model under the restriction PTU=PTE. The resulting estimate for PTU=PTE again equals approximately 0.75, i.e. is much larger than in the static model.

Comparison of the estimates of PTU and PTE for slightly different specifications of the rest of the model shows that these estimates are particularly sensitive to the specification chosen. The fact that, due to the presence of the error term ε_3, we do not observe whether wage rates are equal to the minimum or not, is probably the main reason for this. In Meyer and Wise (1983b), PT has been allowed to depend on the gap between the minimum and the productivity wage rate. From a theoretical point of view, this is an appealing generalization. Preliminary estimation results with our data however yield unsatisfactory results in this respect.[4)]

In the static model, most of the estimates of the slope coefficients in the E^*-equation are significantly different from zero at the 5% level. The effects of the age and education variables, including the product terms, are illustrated in figure 1. This figure presents age patterns of the probability $P[E^*>0]$ for three education levels, with other characteristics set equal to their sample means.



<u>Figure 1</u>. $P(E^*>0)$; Static Model.
—— education level 1; ----- educ. level 3; –·–·– educ. level 5



<u>Figure 2</u>. W^*; Static Model.
—— education level 1; ----- educ. level 3; –·–·– educ. level 5

For males between 30 and 45, the probability is close to 100%. The model will thus attribute most unemployment among these males to minimum wage regulations. Due to the positive sign of the coefficients of LADED3 and LADED45, the graph shifts to the right if the education level increases. In particular, the number of jobless males over 50 with low education level is relatively large. Disability is probably the main explanation.[5)]

There appears to be a significantly negative impact of the unemployment rate in the region on $P[E^*>0]$. This can be explained as a discouraged worker effect: A larger unemployment rate implies smaller chances of finding work, and this may reduce the willingness to search for a job. Being head of the family increases $P[E^*>0]$ significantly, particularly in the presence of children. Single males are less likely to work than others.

In both dynamic versions of the model, the E^*-equation is dominated by the lagged employment dummy DELAG. People who worked last year *ceteris paribus* have a much larger employment probability than those who did not. As has been explained in section 2, this may be explained with labour supply arguments such as habit formation or unobserved heterogeneity. Unobserved heterogeneity which affects demand and cannot be expressed in terms of productivity may also play a role. For example, we did not include variables indicating race or nationality, which might affect both supply and demand.

According to the results for the dynamic model, $P[E^*>0|DELAG=1]$ is almost equal to one except for males of 45 years or over. $P[E^*>0|DELAG=0]$ is small for young males, reaches a maximum of approximately 0.5 between 25 and 35 years of age, and then strongly decreases. For males over 50, the estimated probability of reentering employment is less then 10%. For males of low education level, this probability decreases at an earlier age than for males with a high level of education.

The impact of age and education on the log wage rate W^* according to the static model is illustrated in figure 2. As in figure 1, we have sketched the age pattern for various education levels, with other variables set equal to their sample means. Productivity increases during the largest part of the life cycle, the growth being strongest for the highest education levels. The differences between productivity at various education levels also become apparent. In the dynamic models, the *ceteris paribus* impact of age and education variables is almost the same as in the static model. Most of the standard errors of the parameter estimates are smaller than in the static case.

In the part of The Netherlands called Randstad (the western conurbation), W^* is significantly higher than in the rest of the country.

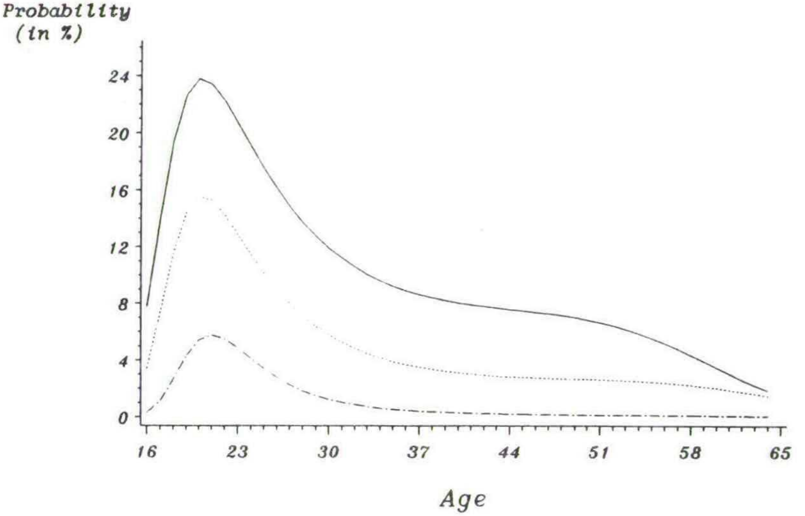
Variables relating to family composition and the regional unemployment rate were not expected to play a large role, if W^* is exclusively determined by productivity and minimum wage regulations. Still, some of the estimates are significantly different from 0. In case of UNP, the negative sign might refer to an impact of the unemployment rate on the power of the firm in the wage bargaining process.[6] Family composition variables might serve as indicators for unobserved productivity heterogeneity, e.g. due to differences in working attitudes.

The estimates of ψ, the coefficient of log M in the W^*-equation, indicate that the minimum wage has a significantly positive impact on the actual wage rate of workers with productivity above the minimum. The hypothesis that these wage rates are exclusively determined by productivity will thus be rejected. Obviously, since variation across sectors is the main source of variation in log M, this conclusion hinges upon the assumption that differences in log M do not reflect *ceteris paribus* productivity differences between sectors.

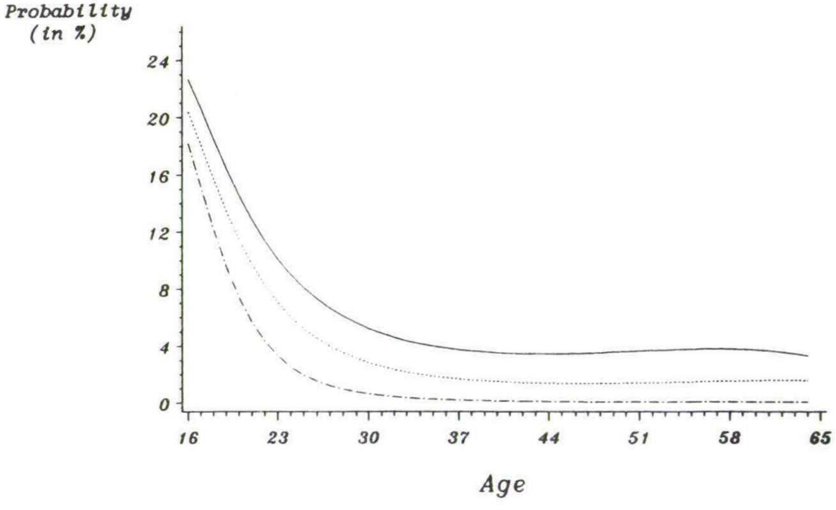
According to the results for the dynamic models, lagged employment significantly affects actual productivity, with the expected positive sign. The role of DELAG in the W^*-equation however is much smaller than in the E^*-equation. This is also reflected by the small differences between the static and dynamic models for the other parameter estimates in the W^*-equation.

This section will be concluded by illustrating the meaning of the results for some representative individuals. In particular, we look at the estimated probability of unemployment due to minimum wage regulations, i.e. $P[E^*>0 \text{ and } W^*<T^*](1-PT)$ in the static model, and the conditional probabilities $P[E^*>0 \text{ and } W^*<T^* | DELAG=0](1-PTU)$ and $P[E^*>0 \text{ and } W^*<T^* | DELAG=1](1-PTE)$ in the dynamic model. As in figures 1 and 2, we look at the age and education pattern, other characteristics set equal to their sample means.

Figure 3 refers to the static model. Unemployment due to minimum wage regulations is substantial for the lowest education level. For young males, the probability is small, mainly due to the large probability $P[E^*<0]$ (see figure 1). Most unemployment due to minimum wage regulations occurs at an age where people have just entered the labour market. For older people, $P[E^*>0 \text{ and } W^*<T^*]$ decreases, mainly because productivity increases (see figure 2).



<u>Figure 3</u>. P(E*>0 and W*<T*)(1-PT); **Static Model.**
—— education level 1; ----- educ. level 3; —·—·— educ. level 5



<u>Figure 4</u>. P(E*>0 and W*<T*)(1-PT). **Dynamic Model** (PTU=0); DELAG=1;
—— education level 1; ----- educ. level 3; —·—·— educ. level 5

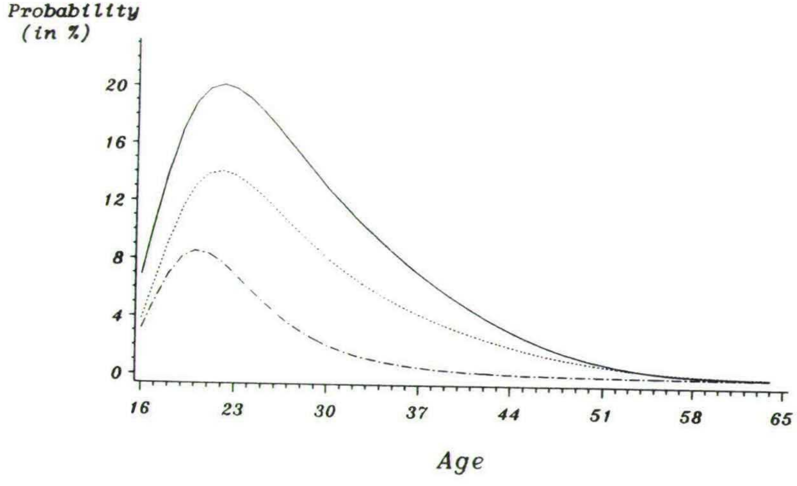


Figure 5. P(E*>0 and W*<T*). Dynamic model (PTU=0); DELAG=0.
—— education level 1; ----- educ. level 3; —·—·— educ. level 5

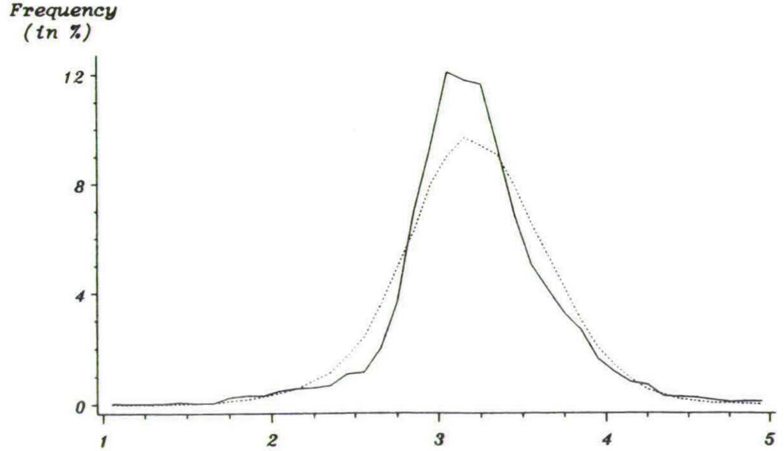


Figure 6. Wage rate distribution. Static Model.
—— sample distribution; ----- simulated distribution

Figures 4 and 5 refer to the dynamic model with PTU=0, for someone with DELAG=1 and DELAG=0, respectively. Unlike in the static model, if DELAG=1, the probability of unemployment due to minimum wage regulations decreases as a function af age. The reason for the difference is that $P[E^*>0|DELAG=1]$ is large for young people also. The age and education pattern in figure 5 resembles that of the static model. On average, the probability of unemployment due to minimum wage regulations according to the dynamic model agrees reasonably well with the static model results.

We do not present graphs for the dynamic model with PTU=PTE. In this case, the pattern of $P[E^*>0 \text{ and } W^*<T^*|DELAG=1]$ is almost the same as in the other dynamic model, with slightly smaller values for young males. The values of $P[E^*>0 \text{ and } W^*<T^*|DELAG=0]$ are much smaller, with a maximum of about 5% at age 22 for people with low educution level. The differences between the two dynamic models correspond to the different values of PTE and PTU.

5. Simulations

The working of the model and the implications of the estimation results can be illustrated with simulations. The first simulation is based on the actual minimum wage regulations. It shows to what extent unemployment is explained by minimum wage regulations. Moreover, comparison of simulated means with sample means sheds some light on the quality of the model.

For each individual, ten random draws were taken from the estimated distribution of the vector of error terms. Next, for each draw, the model predictions of W^*, T^* and E^* were computed. The results were used to obtain average state I and state II probabilities and average wage rates for various age and education categories. Results for the static and the two dynamic versions of the model are presented in table 5.

According to the model, people without a job are either in state I or in state II. In table 5, the simulated probabilities of both states are given (as a fraction of all people in a given age or education category). In case of a perfect fit, these probabilities would add up to the sample fraction of unemployment. For the age and education categories, probabilities and sample fractions agree reasonably well. The static model obviously cannot explain the distinction between unemployment probabilities for those with DELAG=0 and those with DELAG=1. As to be expected, the dynamic models perform much better in this respect.

Table 5. Simulations based on actual minimum wage regulations

Unemployment probabilities:

	Sample		Static Model		Dynamic Model (PTU=0)		Dynamic Model (PTU=PTE)	
	No.	not working	P[I]	P[II]	P[I]	P[II]	P[I]	P[II]
Age:								
16-24	1432	54.05	44.97	9.29	40.89	10.87	46.45	4.39
25-34	2539	11.03	3.79	7.48	6.77	4.53	7.82	3.27
35-44	2422	7.51	1.81	4.23	5.35	2.21	5.89	1.82
45-54	1459	17.61	13.78	3.99	16.71	1.93	17.16	1.64
55-64	1299	55.35	54.24	2.10	53.98	0.99	53.89	0.95
Education:								
1	1728	45.25	34.44	8.66	39.27	6.07	41.69	3.24
2	2013	28.37	20.54	8.08	21.39	6.24	23.83	3.66
3	3838	18.11	13.90	4.83	15.00	3.26	15.82	2.32
4	1086	10.50	9.08	0.99	9.41	0.69	9.50	0.56
5	486	10.29	10.04	0.55	9.26	0.38	9.59	0.31
DELAG:								
0	2282	83.22	42.38	6.38	75.26	7.48	80.56	1.63
1	6869	4.56	10.52	5.32	1.67	2.83	1.72	2.76
All:	9151	24.17	18.46	5.58	20.02	3.99	21.38	2.47

Mean wage rates:

	Sample	Static Model	Dynamic Model	Dynamic Model
Age:				
16-24	12.38	12.27	11.67	11.71
25-34	21.29	21.33	21.35	21.28
35-44	25.01	24.96	25.22	25.23
45-54	25.79	25.50	25.80	25.82
55-64	26.47	26.05	25.61	25.60
Education:				
1	17.57	17.38	17.49	17.42
2	18.26	18.15	17.87	17.87
3	22.37	22.49	22.36	22.33
4	30.47	30.70	30.56	30.50
5	37.05	36.62	36.79	36.85
DELAG:				
0	12.90	17.74	13.09	12.97
1	23.03	23.41	22.96	22.96
All:	22.40	22.34	22.24	22.21

Explanation:

No.: sample number.
Not working: number of non-workers in sample (non-participants included), in % of No.
P[I]: Simulated probability of state I ($E^*<0$) (in % of No.).
P[II]: Simulated probability of state II ($E^*>0$, $W^*<T^*$) (in % of No.).

In a similar way, sample (geometric) average wage rates can be compared with simulated wage rates. The resemblance is quite satisfactory. Again, the dynamic models explain the gap between the average wage rates for those who did and those who did not work the year before. In other respects, the three models perform equally well. These results can be interpreted as a first, though very incomplete, check on the specification of the model.

According to all models and corresponding to what we concluded from figures 4 and 5, unemployment due to minimum wage regulations is substantial for males of low education levels and of less importance for the high education categories. Moreover, we again find rather large differences between the various models. In particular, the dynamic model with PTU=PTE yields relatively low state II probabilities and attributes more unemployment to other causes than minimum wage regulations. As we have stated before, this corresponds to the high values of PTU and PTE in this case. The PTU=PTE dynamic model is not able to reproduce the unemployment fraction in the category DELAG=0 to the same extent as the other dynamic model.

From the second panel of the table, we have concluded that the three models perform well in the sense that they are able to reproduce sample means of wage rates to a large extent. A more thorough specification check can be obtained if, for given categories, the sample distribution of wage rates is compared with the simulated distribution. We first present some illustrative graphs.

In figure 6, the wage distribution in the sample has been sketched, together with the simulated distribution for the static model. Log wage rates are grouped into intervals of width 0.10. The figure relates to people of all age and education categories, irrespective of lagged employment status. Apparently, the wage distribution is tracked to a large extent, but not completely. The peak in the sample distribution at about Dfl 20 to Dfl 26 per hour is not completely reproduced.

Figures 7 and 8 relate to the dynamic model with PTU=0, for those with DELAG=1 and with DELAG=0, respectively. Figure 7 leads to the same conclusions as figure 6. The way in which the wage distribution of people with DELAG=0 is reproduced seems quite satisfactory, considering the relatively small number of observations upon which the sample distribution is based.

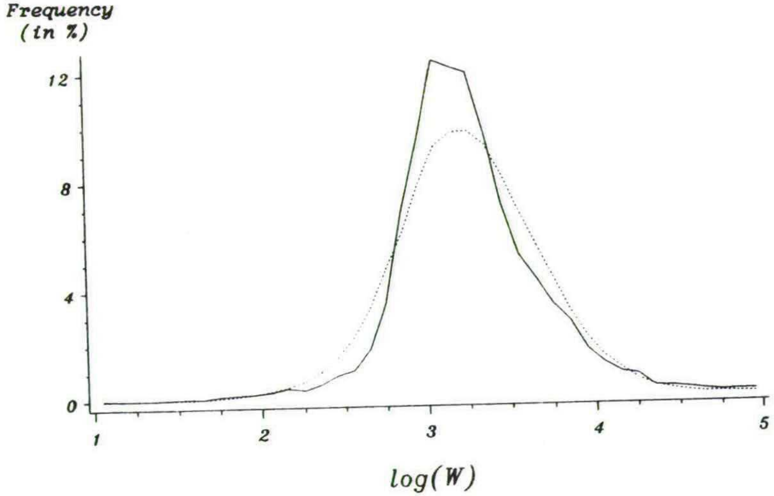


Figure 7. Wage rate distribution. Dynamic Model (PTU=0); DELAG=1.
——— sample distribution; ----- simulated distribution

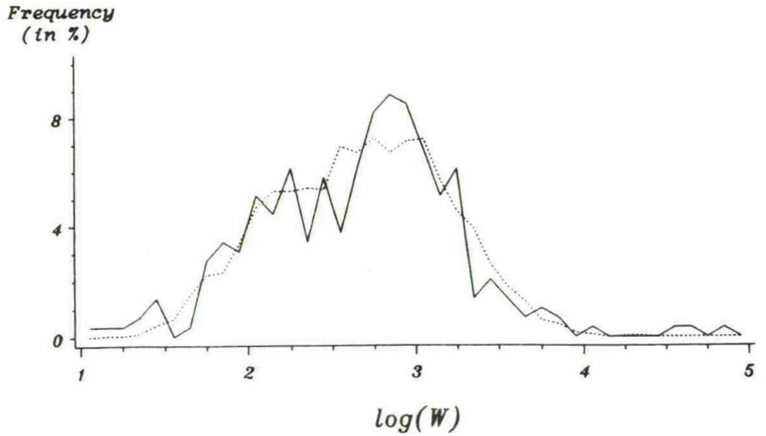


Figure 8. Wage rate distribution. Dynamic Model (PTU=0); DELAG=0.
——— sample distribution; ----- simulated distribution

Formal specification tests based on this type of comparisons are chi-square diagnostics as discussed by Heckman (1984) and Andrews (1988). These tests are based on partitioning the sample space into a given number of cells and comparing, for all observations, sample probabilities with predicted probabilities. In case of ML-estimation, the test statistic is given by the explained sum of squares in a regression of the vector $(1,\ldots,1)'\in\mathbb{R}^n$ (where n is the number of observations) on the scores and the differences between observed and predicted cell probabilities.[7] We constructed cells as products of a partition of the space of exogenous variables (X) into G_x cells and the space of endogenous variables (Y) into G_y cells, implying that, under the null of no misspecification, the test statistic is chi-square distributed with $G_x(G_y-1)$ degrees of freedom.

For Y, we used a partition with $G_y=6$ cells: non-workers, and workers divided according to their wage rates: wage rate less than Dfl 15.86, between Dfl 15.86 and Dfl 19.62, between Dfl 19.62 and Dfl 25.81, more than Dfl 25.81, and wage rate unknown.[8] For X we used the partition with one cell only and partitions into age or education categories. The test results indicate that the static model as well as the dynamic models are misspecified.

Some idea of possible directions of misspecification can be obtained with Lagrange multiplier tests. In particular, a number of model assumptions are rejected, such as homoskedasticity of the error term ε_2, the assumption that PT does not depend on exogenous variables, the lognormal nature of the wage rate distribution (using Box Cox transformations as an alternative), and the fact that the difference between the relevant minimum and the observed sector minimum has mean zero and does not vary with age.

The problem with these tests is however that, as soon as one source of misspecification is present, tests in other directions of misspecification are no longer valid. The fact that in several cases the null hypothesis is rejected therefore does not indicate in which direction extension is needed, although the magnitudes of the test statistics suggest that heteroskedasticity might be the most important one.

Elasticities

In order to obtain some insight in the sensitivity of employment and average wage with respect to changes in minimum wage regulations, we repeated the simulation exercise described above after reducing all minimum wage rates by 10%. In table 6 we present deviations between simulated figures based on actual and reduced minimum wage rates. Note that all figures should be interpreted in a *ceteris paribus* framework: It is assumed that the productivity and participation relations do not shift. This limits the macro-economic implications of these simulation results.

The sensitivity of employment with respect to minimum wage regulations strongly depends on the extent to which unemployment is explained by minimum wage regulations. This explains why the elasticity decreases with education and age. According to the static model, the elasticity of youth employment is -0.42. On average, if someone's relevant minimum would fall by 10%, the probability that he is employed would rise by 1.93%.

In the dynamic model, short run and long run effects are distinguished. The only dynamics taken into account are those related to the lagged unemployment variable. Time trends (reflected by D86 and D87) and changing age or education composition of the sample are ignored.

As in the static model, reducing minimum wages directly increases employment probabilities, since more workers will have a productivity exceeding the minimum wage. The larger employment probability leads to an extra employment increase next year for several reasons. Unemployment not due to minimum wage regulations decreases, because of the strong positive impact of lagged employment on the probability $P[E^*>0]$. Moreover, labour market experience on average increases and this leads to an increase in productivity. This effect is reflected by the positive impact of DELAG on W^*. In the model with PTU=0, the difference between PTE and PTU is a third reason, since in this case, only previously employed workers may work with productivity below the minimum.

In the dynamic model with PTU=0, the short run employment effect is smaller than in the static model. In the long run however, the effect is larger. After three years, it is about twice as large as the short run effect. In the dynamic model with PTU=PTE, employment effects are much smaller than in the other dynamic model. Still, the long run elasticity of employment with respect to minimum wage regulations exceeds the elasticity in the static model.

Table 6. Simulation of a reduction of all minimum wage rates by 10%

Static Model	employment	wage rate
Age:		
16-24	4.17	-3.53
25-34	2.29	-2.92
35-44	1.34	-2.50
45-54	1.38	-2.54
55-64	1.52	-2.67
Education:		
1	3.44	-3.33
2	2.97	-3.20
3	1.68	-2.61
4	0.49	-2.04
5	0.14	-1.82
All:	1.93	-2.92

Dynamic Model (PTU=0)

	year 1		year 2		year 3		year 4		year 5	
	empl.	wage	empl.	wage	empl.	wage	empl.	wage	empl.	wage
Age:										
16-24	4.35	-4.07	5.95	-3.79	6.77	-3.67	7.28	-3.62	7.63	-3.60
25-34	1.35	-2.90	2.08	-2.89	2.52	-2.89	2.80	-2.90	2.99	-2.90
35-44	0.72	-2.46	1.18	-2.50	1.49	-2.53	1.72	-2.55	1.89	-2.57
45-54	0.61	-2.45	1.12	-2.51	1.55	-2.57	1.91	-2.62	2.23	-2.67
55-64	0.70	-2.54	1.32	-2.64	1.86	-2.73	2.34	-2.81	2.78	-2.90
Education:										
1	2.15	-3.54	3.52	-3.61	4.48	-3.64	5.22	-3.66	5.79	-3.66
2	2.11	-3.46	3.24	-3.44	3.93	-3.44	4.41	-3.43	4.76	-3.43
3	1.07	-2.74	1.72	-2.78	2.14	-2.80	2.43	-2.81	2.65	-2.82
4	0.25	-2.09	0.40	-2.11	0.50	-2.12	0.58	-2.12	0.64	-2.13
5	0.12	-1.94	0.18	-1.94	0.21	-1.95	0.24	-1.95	0.26	-1.96
All:	1.26	-3.01	2.00	-3.13	2.49	-3.20	2.84	-3.26	3.10	-3.30

Dynamic Model (PTU=PTE)

	year 1		year 2		year 3		year 4		year 5	
	empl.	wage	empl.	wage	empl.	wage	empl.	wage	empl.	wage
Age:										
16-24	1.74	-3.72	2.59	-3.48	3.14	-3.38	3.53	-3.33	3.82	-3.31
25-34	0.96	-2.27	1.50	-2.25	1.83	-2.24	2.04	-2.24	2.18	-2.24
35-44	0.64	-1.80	1.04	-1.82	1.30	-1.83	1.49	-1.85	1.63	-1.86
45-54	0.64	-1.83	1.18	-1.89	1.63	-1.95	2.02	-1.99	2.35	-2.04
55-64	0.62	-1.85	1.17	-1.92	1.66	-1.98	2.11	-2.04	2.53	-2.11
Education:										
1	1.44	-2.92	2.41	-2.88	3.10	-2.85	3.63	-2.82	4.05	-2.80
2	1.22	-2.68	1.95	-2.63	2.45	-2.61	2.81	-2.60	3.08	-2.60
3	0.80	-2.03	1.31	-2.03	1.66	-2.04	1.92	-2.04	2.11	-2.05
4	0.24	-1.36	0.40	-1.38	0.51	-1.39	0.59	-1.40	0.65	-1.41
5	0.12	-1.20	0.17	-1.20	0.21	-1.21	0.24	-1.21	0.26	-1.21
All:	0.85	-2.23	1.40	-2.28	1.78	-2.32	2.06	-2.35	2.27	-2.38

The sensitivity of the average wage rate with respect to minimum wages has three sources. First of all, wages of minimum wage earners fully respond. The impact of this on the average wage rate depends on the number of people with low productivity and the value of PT (or PTU and PTE). As a consequence, this effect is largest for those age and education categories which, on average, contain most workers with low productivity. Secondly, wages of all workers with productivity above the minimum respond with elasticity ψ, i.e. 0.16 in the static model and 0.18 and 0.10 in the two dynamic models. As a consequence, the average wage in high productivity categories is also affected.[9)] In the third place, the average wage rate is negatively affected because of the employment change. The number of low productivity workers increases, and thus the average wage rate decreases. In the dynamic models, there is also an effect in the opposite direction, since the employment growth leads to a higher average productivity next year.

According to the static model, the elasticity of the average wage rate with respect to the minimum is -0.29. In the dynamic models, differences between long run and short run elasticities only stem from the indirect effect through employment and thus appear to be rather small. In the dynamic model with PTU=0, the elasticities are -0.30 and -0.33 in the short and long run, respectively. In the other dynamic model, elasticities are smaller, mainly because of the smaller estimate of ψ.

6. Conclusions

In this paper, we have looked at the impact of minimum wage regulations from a micro-econometric point of view. Our models extend those in Meyer and Wise (1983a). Using sector variation across minimum wage rates, we are able to identify the extent to which minimum wage regulations affect wages of workers with productivity exceeding the minimum. Thus it is possible to relax the assumption that these wage rates are exclusively determined by the worker's productivity. The wage rate is modelled as the outcome of a wage bargaining process, in which marginal productivity and minimum wage are the threat points of employer and employee, respectively. Estimation results suggest that this is a significant improvement.

In our model, the minimum wage is treated as an unobservable variable, which consists of an observed sector average and a mean zero error term. As a consequence, we do not observe whether workers earn exactly the minimum or not, even if the actual wage rate is observed without error. This makes it more difficult to estimate some parameters of the model, including those determining the distinction between unemployment due to minimum wage regulations and other reasons for not working.

This problem is somewhat similar to problems in neoclassical labour supply models, in which the shape of the hours distribution must be used to distinguish between e.g. measurement errors and random preferences or to identify unobserved fixed costs or hours constraints. See, e.g., Moffitt (1986). As a result, parameter estimates may be sensitive to the specification of the rest of the model.

In our case, this seems to apply particularly to the parameters PT and PTE and PTU: The estimates of these parameters vary substantially with the exact choice of model specification. As a consequence, the estimated importance of minimum wage regulations as a source of unemployment varies. Still, for all specifications we find significant evidence for a substantial negative impact of minimum wage rates on employment and a positive link between the minimum and average wage levels. This conclusion does not only hold for the results presented in this paper, but also for those based upon similar models estimated with data for the same Dutch panel. See Van Soest (1989), Van Soest and Kapteyn (1989) and Van Soest and Kapteyn (1990).

With the static model, we find *ceteris paribus* elasticities of employment with respect to minimum wages of -0.42 for youth and -0.19 for all males. The youth elasticity is rather large compared to the results obtained by Meyer and Wise. This might be explained by the fact that in The Netherlands the level of minimum wage rates is relatively higher than in the US. Youth as well as adults elasticities are large if compared to US time series results (see Brown et al., 1982). On the other hand, our result for youth is well in line with those based on French macro-economic time series data obtained by Bazen and Martin (1988). They find long run wage elasticities of -0.42 for youth and -0.05 for adults. The estimated elasticities of the average wage rate with respect to the minimum in our static model are 0.35 for youth and 0.29 for all males, which is also well in line with the results of Bazen and Martin (1988).

The dynamic structure of the dynamic models we have estimated is limited. The only lagged variable included is a dummy indicating the employment status one year before. This variable is allowed to play a role in several ways. We find that short run effects are smaller than long run effects and thus do not find proof of 'overshooting', as in Bazen and Martin's time series study. The total employment effect of a minimum wage change after three years is about twice as large as the effect in the first year. The long run effect on the average wage rate only exceeds the short run effect by a small amount. The effects found with the dynamic model seem reasonably well in line with those in the static model.

Several checks on the specification of the model are preformed. The model predictions of average employment probabilities and average wage rates for various age and education categories resemble the corresponding sample means quite well. However, comparison of the predicted wage distribution with the sample distribution, as well as various formal tests, suggest that at least some misspecification is present. Several further generalizations of the model can and have been suggested, but it is not clear whether the data at hand permit fruitful estimation of these models. More explicit information would certainly be worthwile, e.g. on sectors or relevant minimum wage rates, on whether or not someone's wage is determined by some sector minimum, on why someone is not employed, etc.

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Notes

1) See e.g. Welch (1976) and Leighton and Mincer (1981) for theoretical studies on the positive effect of minimum wage regulations on the level of education, and thus on productivity growth. Our model does not incorporate this effect: the education level is an exogenous variable.

2) Van Opstal (1990) describes data on wage rates collected from firms. He finds some peak in the wage distribution for young workers (males and females) in 1985 but not for male adult workers. He also finds that the number of minimum wage earners has decreased substantially between 1979 and 1985.
We also estimated the static model with both ε_3 and a measurement error in observed wage rates. The estimated standard error of the measurement error however turned out to be zero.

3) The estimate mentioned refers to people whose sector is known. See section 2.

4) The concerning coefficient has the wrong sign and is insignificantly different from 0. In order to avoid computation of trivariate cumulative normal probabilities, $\Sigma(1,2)$ is set equal to 0.

5) The number of people entitled to disability benefits in The Netherlands is relatively large if compared to other industrialized countries. In our data set, more than 30% of all males over 45 with a low education level receive disability benefits. See Aarts and de Jong (1990) for a detailed study of this issue.

6) This could be incorporated explicitly by allowing γ to depend on UNP.

7) The observed probability is one if the observation belongs to the cell and zero otherwise. The predicted probability is the probability that the individual belongs to the cell, given the exogenous variables and the parameter values.

8) These cell boundaries are the 0.25-, 0.50- and 0.75-quantiles of the distribution of sample wage rates.

9) In Van Soest and Kapteyn (1989), a model is discussed in which the assumption that wages of all workers with productivity above the minimum are affected is generalised. In that paper, above productivity workers are divided in two groups. In one group, the minimum does affect the wage, whereas in the other group, consisting mainly of high wage earners, it does not.

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